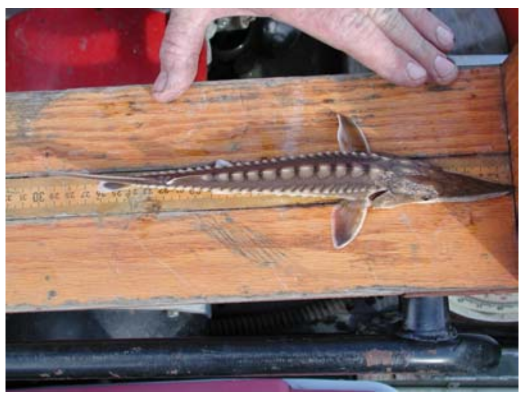
FINAL REPORT

February, 2004

Quantitative assessment of benthic food resources for juvenile Gulf sturgeon, *Acipenser oxyrinchus desotoi* in the Suwannee River estuary, Florida, USA.



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U.S. Geological Survey

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U.S. Geological Survey
Eastern Region
Florida Integrated Science Center

QUANTITATIVE ASSESSMENT OF BENTHIC FOOD RESOURCES FOR JUVENILE GULF STURGEON, *ACIPENSER OXYRINCHUS DESOTOI,* IN THE SUWANNEE RIVER ESTUARY, FLORIDA, USA.

Final Report
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Figure Legends

Figure 1. The Suwannee River, Florida, with a circle inset which encloses the estuarine river mouth area (rkm 0-2.5) utilized as trophic habitat by juvenile Gulf sturgeon.

Figure 2. Five different sectors of the Suwannee River Estuary based upon salinity regimes.

Figure 3. The location of the random sampling sites used in this study. The triangles indicate June-July, 2002, samples (n=156) and the circles indicate February-April, 2003, samples (n=103).

Figure 4. A) Comparative mean abundance (number of individuals/m^2 ± 95% C.I.) of benthic macrofauna (> 0.5 mm) from core samples in the Suwannee River estuary. B) Comparative mean biomass (g dry wt./m^2 ±s.e.) of benthic macrofauna (> 0.5 mm) from core samples in the Suwannee River estuary. Location abbreviations are as follows: WDP – Wadley Pass, EP – East Pass, NS – North Sound, SS – South Sound, and WP – West Pass.

Figure 5. Interpolated map of macrofaunal density (number of individuals/m^2) in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 6. Interpolated map of benthic biomass (g dry wt./m^2) of benthic macrofauna in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 7. Relative composition of benthic macrofaunal taxa from core samples in the Suwannee River estuary.

Figure 8. Interpolated map of amphipod density (number of individuals/m^2) in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 9. Interpolated map of polychaete density (number of individuals/m^2) in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 10. Interpolated map of brachiopod density (number of individuals/m^2) in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 11. Interpolated map of the density (number of individuals/m^2) of macrofauna which fall into the Principal Foods category in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 12. Interpolated map of the Biased Food Density (number of individuals/m^2) estimate based upon core samples taken in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 13. Interpolated map of the Adjusted Food (g dry wt./m^2) estimate based upon core samples taken in the Suwannee River estuary during the summer of 2002 (A) and winter of 2003 (B).

Figure 14. The location of the places within the Suwannee River Estuary that juvenile (,1 m) Gulf sturgeon and the number which have been caught, USGS sampling 1988-1995.

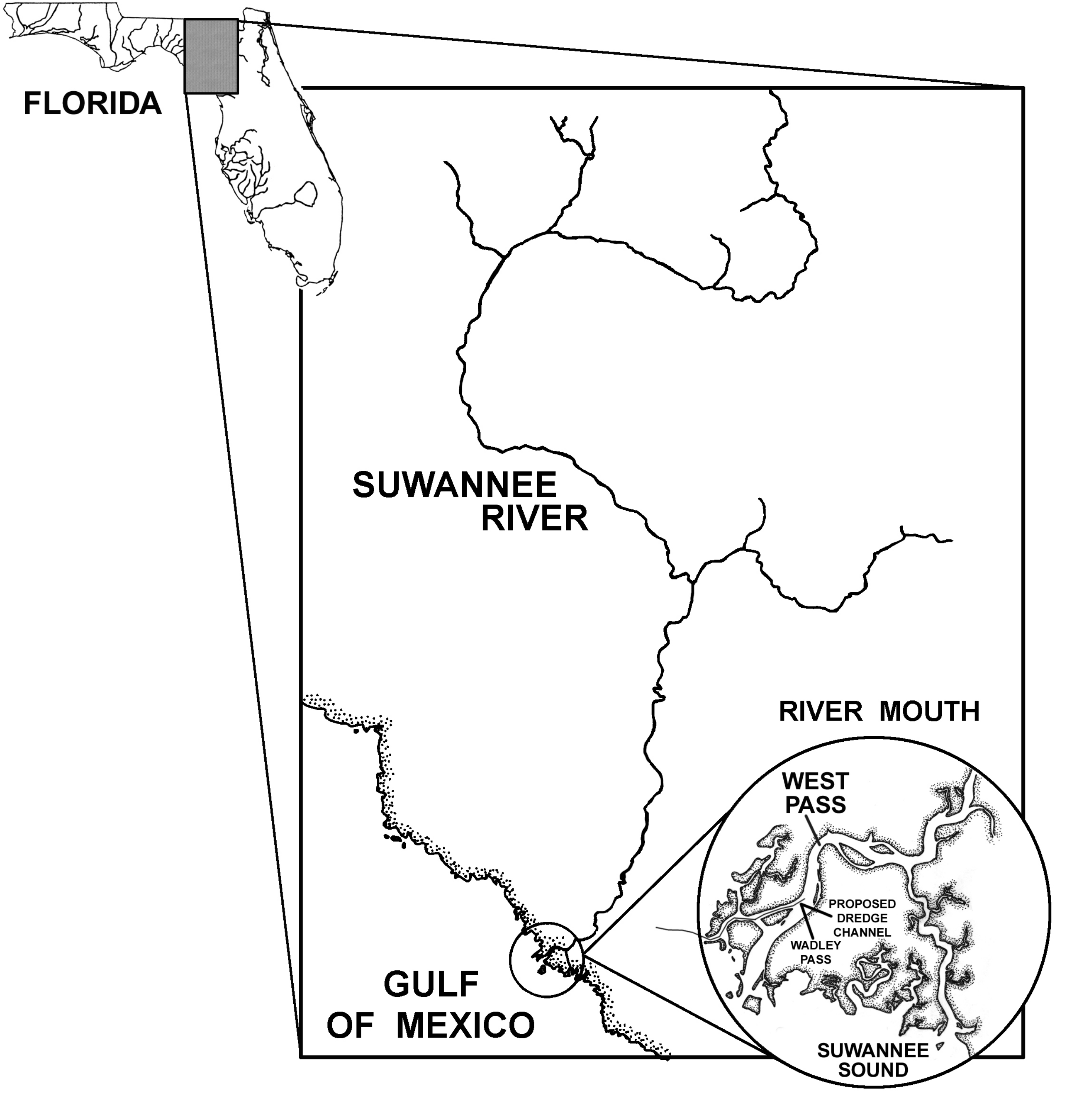
Abstract

Gulf sturgeon, *Acipenser oxyrinchus desotoi*, forage extensively in the Suwannee River estuary following emigration out of the Suwannee River. While in the estuary, juvenile sturgeon primarily feed on benthic infauna. In June-July, 2002, and Feb-April, 2003, random sites within the estuary were sampled for benthic macrofauna (2002, n=156; 2003, n=103). A mean abundance of 2,562 individuals/m^2 (s.e. $\pm$ 204) was found in the summer, with significantly reduced macrofaunal abundance in the winter (mean density of 1,044 individuals/m^2, s.e. $\pm$ 117). Benthic biomass was significantly higher in the summer with an average summer sample dry wt. of 5.92 (s.e. $\pm$ 0.82) g/m^2 compared to 3.91 (s.e. $\pm$ 0.67) g/m^2 in the winter. Amphipods and polychaetes were the dominant taxa collected during both sampling periods. A Principal Food estimate indicated that the potential food resource value for juvenile Gulf sturgeon is spatially heterogeneous within the Suwannee River estuary.

Introduction

The Gulf sturgeon, *Acipenser oxyrinchus desotoi*, was designated as threatened by the U.S. Fish and Wildlife Service in 1991, under the U.S. Endangered Species Act of 1991. Subsequently, there has been a need to acquire information related to locating and characterizing their critical habitats (USFWS and Gulf States Marine Fisheries Commission, 1995). The largest population of Gulf Sturgeon utilizes the Suwannee River, Florida, and estuary (Sulak & Clugston, 1998). Prior to spring spawning, sturgeon from offshore begin pre-migratory staging around mid-February with movement into the lower river from the estuary. After spawning up-river in March-April, Gulf sturgeon reside in the river, fasting until October-November (Mason & Clugston 1993). When they emigrate back to the estuary, Gulf sturgeon begin active foraging to replace lost energy reserves. Sturgeon over the age of five/six spend the winter beyond the estuary, but juveniles remain and feed in the estuary during the winter (Fox & Hightower, 1998; Sulak & Clugston, 1998). Recent analysis indicates that some juveniles age 1-6 remain and feed in the estuary year round (USGS 17 year Suwannee River Gulf Sturgeon Database).

Three passes (inlets), two with previously dredged navigation channels exist within the mouth of the Suwannee River. None of the channels are currently maintained for navigation all have become sediment-filled over time. The U.S. Army Corps of Engineers (USACE) has proposed to dredge one inlet, Wadley Pass, in an area probably used as feeding habitat by juvenile sturgeon (F&W Coordination Act Report: GEC, 2002). The channel is planned to be approximately 25 m wide by 3 m deep extending for approximately 2.5 miles (Figure 1). It has been proposed that the dredge material be placed subtidally adjacent to Cat, Little Bradford, and No-Name Island to aid in shoreline stabilization (F&W Coordination Act Report: GEC, 2002). Of concern is how maintenance dredging and/or spoil disposal will impact the threatened and endangered species which are known to inhabit the Suwannee Estuary (e.g., West Indian Manatee, Gulf sturgeon).


FLORIDA
SUWANNEE RIVER
RIVER MOUTH
WEST PASS
PROPOSED DREDGE CHANNEL
WADLEY PASS
GULF OF MEXICO
SUWANNEE SOUND

Juvenile sturgeon have been found to consume primarily benthic infauna while in the estuary (Huff, 1975; Mason & Clugston 1993). Thus, any alterations within the estuary that changes either sediment grain size/sorting or chemistry may impact juvenile food resources (Kenny & Rees, 1996; Seiderer & Newell, 1999). In order to prevent disruption of sturgeon migration patterns, the date of dredging has been restricted to between May 15th and October 15th while the majority of the sturgeon are still upriver. However, benthic macrofauna recovery from dredging may require a longer time frame (De Grave & Whitaker, 1999) limiting available food resources for juvenile Gulf sturgeon within the estuary.

Gulf sturgeon feed only in the marine environment (Mason & Clugston, 1993; Gu *et al.*, 2001), with adults and juveniles foraging extensively in the estuary during winter (November to February-March) (Mason & Clugston 1993). Therefore, it is imperative to acquire food resource information for this critical area. Analysis of the current benthos status will allow for informed management of future actions in the estuary, and can be used to minimize impact to sturgeon trophic habitat. Most environmental impact studies do not have a pre-impact baseline and rely upon what appear to be relatively similar sites to represent "control areas". This study allowed acquisition of quantitative "before" samples which can be used to comparatively evaluate post-dredging changes. Two objectives regarding macroinfauna within the Suwannee River Estuary are addressed in this study: 1) Determination of the spatial distribution, abundance, and biomass of potential food resources for juvenile Gulf sturgeon. 2) Evaluation of quantitative methods for predicting which estuarine areas are potentially most important in providing food resources for juvenile sturgeon.

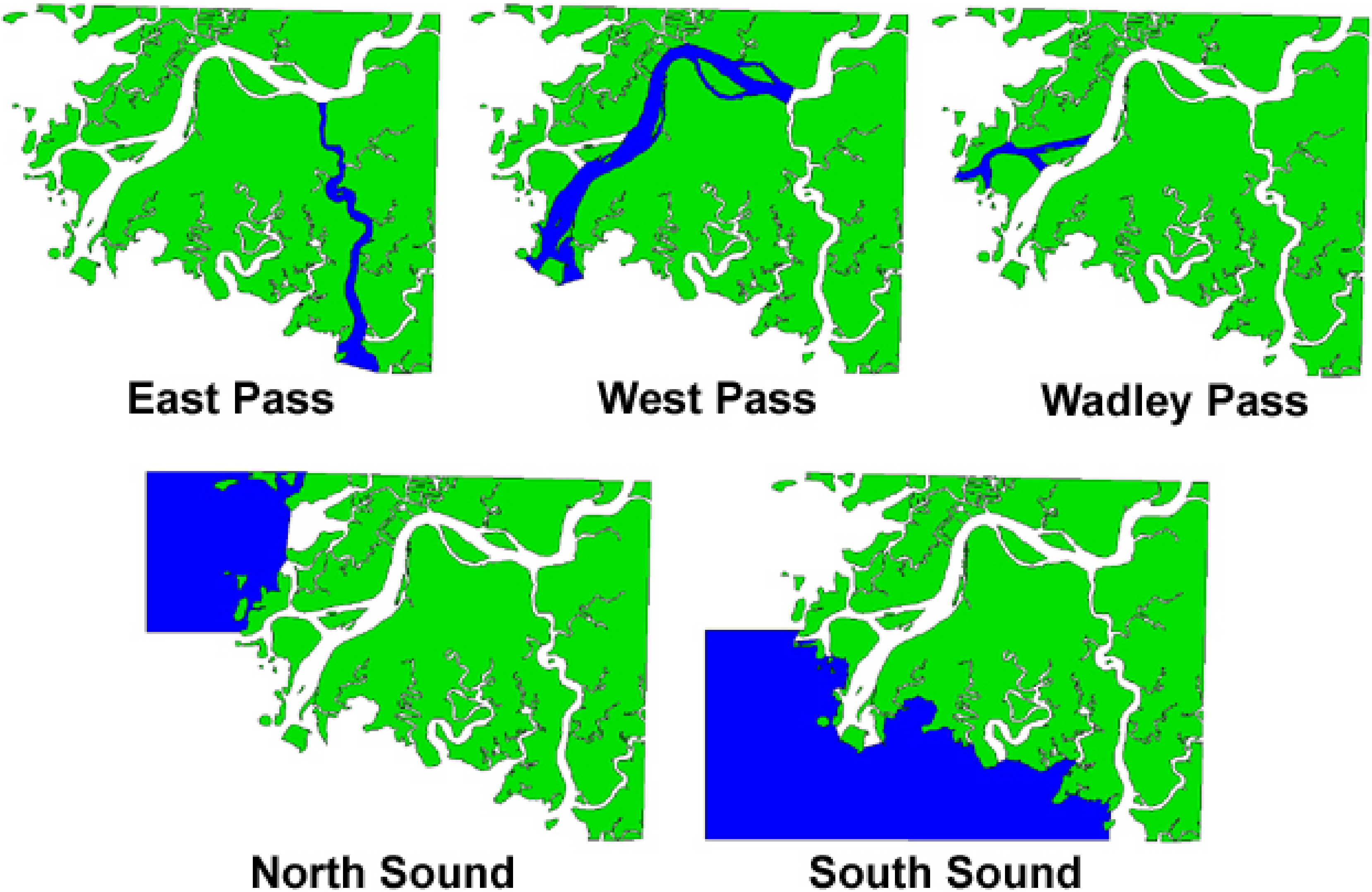
Methods

A) Study Area

The Suwannee River is one of Florida's largest rivers and has an average flow of 299.6 m^3 s^{-1} (Mattson, 1992) (Figure 1). The river is not dammed, and the mouth of the river receives a substantial freshwater plume (Mattson, 1992; Mason et al., 1994). The Suwannee River Estuary is separated from the Gulf of Mexico by a series of oyster reefs. It can be divided up into five sectors differing in salinity (Figure 2). The river has three main exits into the Gulf of Mexico – West Pass and East Pass that are natural passes, and Wadley Pass which is man made. West Pass receives the main outflow of freshwater. The estuarine sound can be separated into two parts, North and South Sound. The South Sound receives substantial freshwater input directly from West Pass. However, the North Sound generally does not receive as much same freshwater input and usually maintains more saline conditions. We hypothesized that the five sectors of the estuary, Wadley Pass, West Pass, East Pass, North Sound, and South Sound, would differ in benthic community parameters based upon salinity and freshwater input (Kimmerer, 2002).

B) Benthos Sampling

A virtual grid of 100 m x 100 m cells was projected over the entire Suwannee Estuary.


East Pass
West Pass
Wadley Pass
North Sound
South Sound

In June-July, 2002 156 random sites and in Feb-April, 2003 103 random sites, were selected for sampling (Figure 3). Random sites were allocated equally among the five different sectors of the estuary (treated as five strata) discussed above and located in the field using a Garmin GPSMAP 76S. At each sampling site, a benthic core was taken to sample macrofauna (> 0.5mm in size). The core taken was 15 cm in diameter and 15 cm deep. Each core sample was sieved through a 0.5 mm mesh in the field. For each sample subsurface salinity (0.5 m depth), water temperature, dissolved oxygen content, and pH were measured using a YSI 6000 handheld multimeter. Upon return to the laboratory, all macrofauna were identified to lowest possible taxon. Dry weight (to the nearest 0.001 g) of each sample was determined after drying for 24 hours at 60° C. All bivalve and gastropod shell material was discarded prior to dry weight determination. Polychaetes were identified by specialists at the Atlantic Reference Centre of the Huntsman Marine Science Centre, St. Andrews, New Brunswick, Canada. Amphipods were identified according to Bousfield (1973).

Statistical Analysis

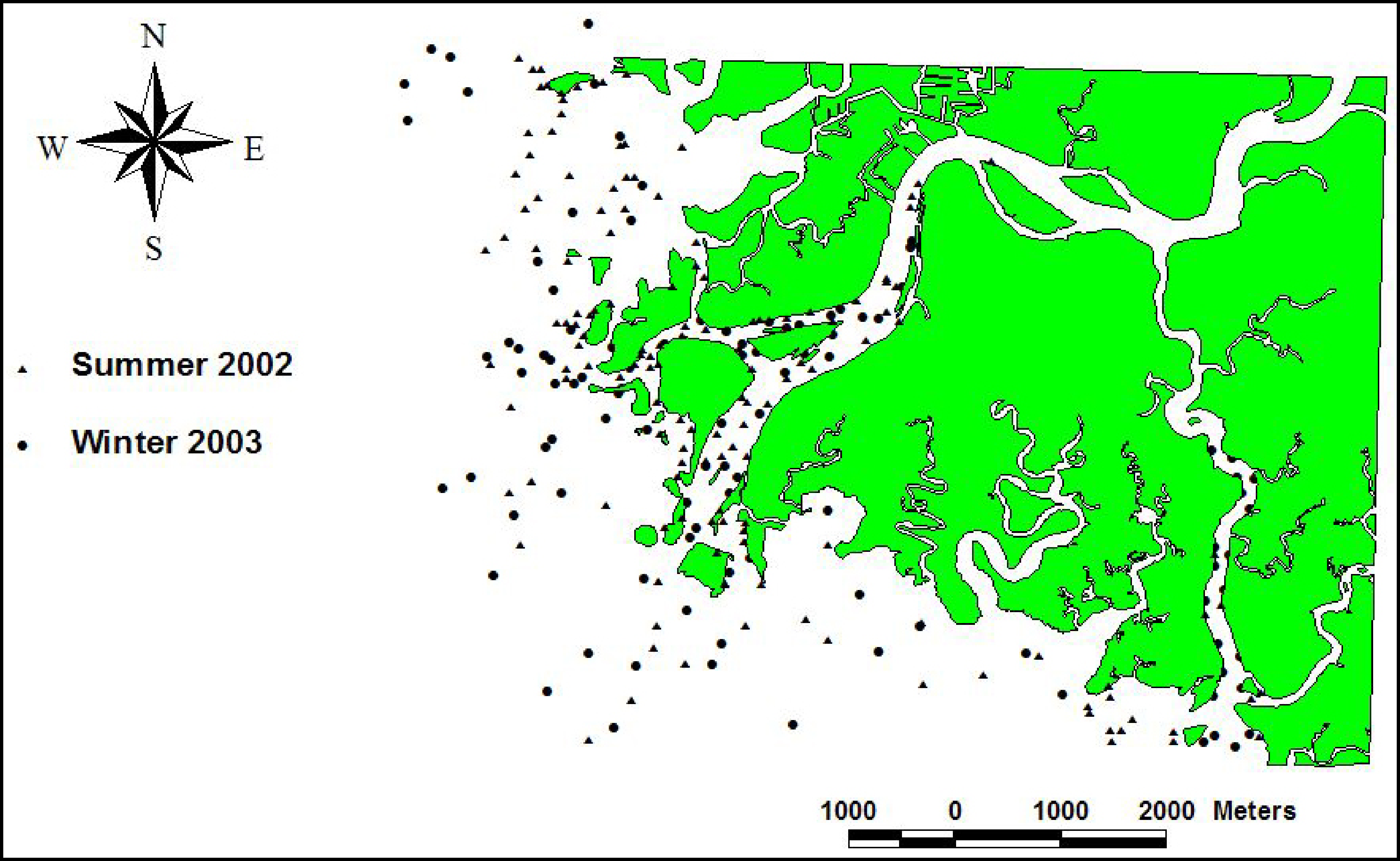
A) Fauna Abundance and Distribution

Due to a lack of normality and homogeneity of variances among the data, all data were compared using nonparametric statistical comparison techniques. Mann-Whitney Rank Sum Test was used to test for significant differences in macrofaunal density and biomass based upon season, summer (July) versus winter (February-March). The summer and winter sampling intervals also corresponded to dry (low flow) versus wet (high flow) times of the year, respectively. Kruskal-Wallis ANOVA on Ranks comparisons was used to test for significant differences in macrofaunal density, macrofaunal biomass, amphipod density, and polychaete density among the five estuarine sectors (Figure 2) for each season separately. If Kruskal-Wallis results indicated a significant treatment effect, Dunn's Method multiple comparison tests were subsequently performed to determine significant differences (Glantz, 1997).

The point values (i.e., macrofauna density, macrofauna biomass, amphipod density) for each sample were used to create interpolated maps of the study area, using an Inverse Distance Weighting (IDW) method in the Spatial Analyst extension of ArcView 3.2. An edit mask was used to exclude all land cover and constrain the interpolation to only the sampled area. IDW is an interpolation technique in which estimates are made based on values at nearby locations weighted only by distance from the interpolation location. IDW does not make assumptions about spatial relationships except the basic assumption that nearby points are more closely related than more distant points. Twelve neighbors were used for the interpolation (power of two and cell size of 100 m).

B) Principal Foods Analysis

Two studies have examined gut contents of juvenile Gulf sturgeon. Huff (1975) found that guts of juveniles in the Suwannee River Estuary feed upon non-tube building amphipods, isopods, insect larvae and mud shrimps. Mason & Clugston (1993) found similar prey in juvenile Gulf sturgeon gut contents, including non-tube building


N
W
E
S
Summer 2002
Winter 2003
1000 0 1000 2000 Meters

crustaceans and insect larvae, with relatively few organisms that possess either a hard carapace or shell. Heard et al. (2002), did not examine gut contents, but stated that juvenile Gulf sturgeon consume non-tube building amphipods. After review of these studies, three different principal food categories (Principal, Secondary, and Minor) were established (Table 1).

Using these three food categories, three ways to predict potential food resources for juvenile Gulf sturgeon were examined:

1) Principal Food Density – This estimate is simply the density (individuals/m^2) of macrofauna which fall into the Principal Foods category. Using only the density of Principal Food items, however, ignores the Secondary and Minor Food categories.

2) Biased Food Density – The density of macrofauna (individuals/m^2) was weighted by food category: Biased Food Density = [(1.0*Principal Food items /m^2)+(0.66*Secondary Food items /m^2)+(0.33*Minor Food items/m^2)]". The Biased Food Density estimate does not take benthic biomass (*i.e.*, energy) into account.

3) Adjusted Biomass – The Adjusted Biomass estimate was derived to take food categories and biomass into account. First, the Biased Food Density estimate was used to derive a Food Index for each sample: "Food Index = Biased Density / Total Density". The Food Index returns a value between 0 and 1 for each sample. Higher index values indicate a greater abundance of foods in the Principal Food category. The food index for each sample was then combined with the sample biomass (g/m^2) to derive an Adjusted Biomass estimate: "Adjusted Biomass = Overall Biomass* Food Index".

Results

A) Faunal Abundance and Distribution

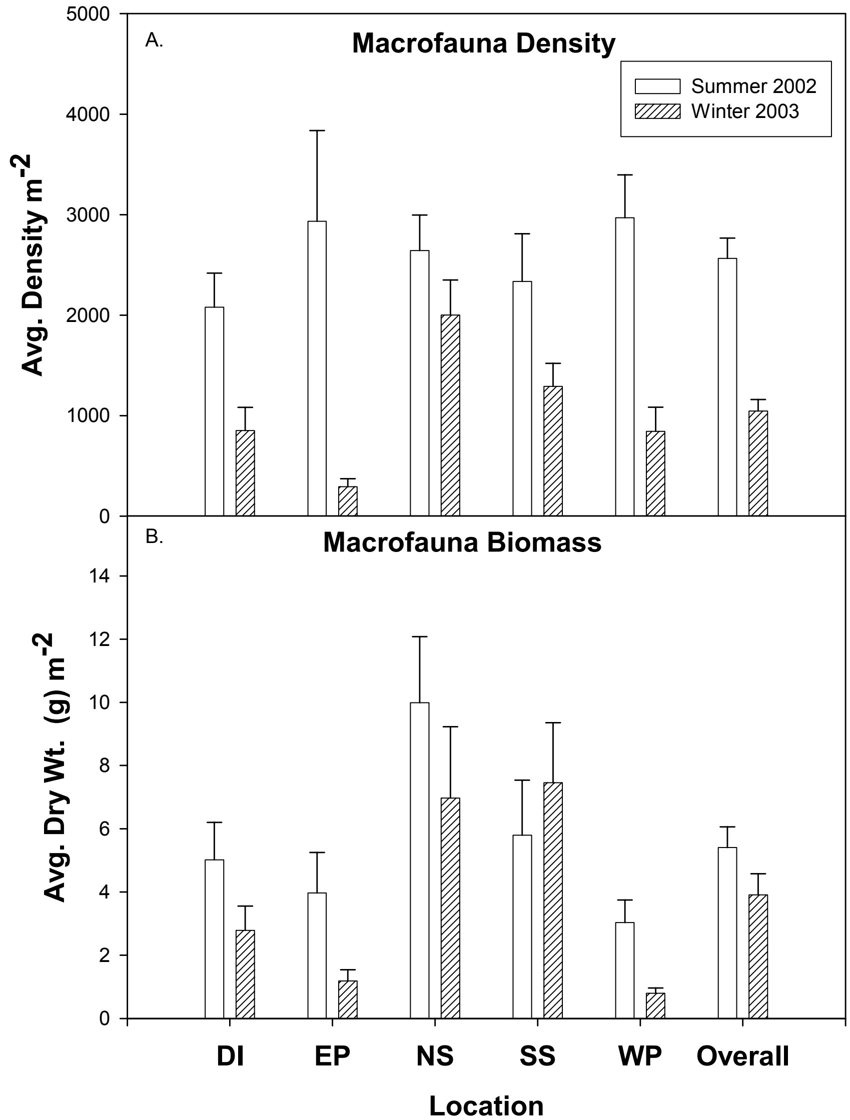
In the summer samples, 6,618 individuals were collected with an average of 2,562 macrofauna/m^2 (95% C.I. $\pm$ 403). Macrofauna abundance was significantly (P=0.001, Mann-Whitney Rank Sum Test) reduced in the winter with 1,900 individuals collected for an average density of 1,044 macrofauna/m^2 (95% C.I. $\pm$ 232). Benthic biomass was significantly higher in the summer (P=0.015, Mann-Whitney Rank Sum Test) with an average summer dry wt. of 5.92 (95% C.I. $\pm$ 1.3) g/m^2 compared to 3.91 (95% C.I. $\pm$ 1.3) g/m^2 in the winter.

Macrofaunal density was not significantly different among the five estuarine sectors in the summer (P=0.388, ANOVA on Ranks, Figure 4a). However, from an interpolated map of macrofauna density, it is apparent that density is not homogenous but rather patches of high density exist (Figure 5a). Specifically, areas of high density can be found throughout Suwannee Sound and in part of the West Pass sector. A significant difference in macrofaunal density was found among the five sectors during the winter (P=0.001, ANOVA on Ranks, Figure 4a). Both the North Sound and South Sound sectors had significantly higher infaunal density than the East Pass sector. An interpolated map for the winter also shows areas of relatively high density in the Suwannee Sound (both sectors) and parts of the West Pass sector (Figure 5b).

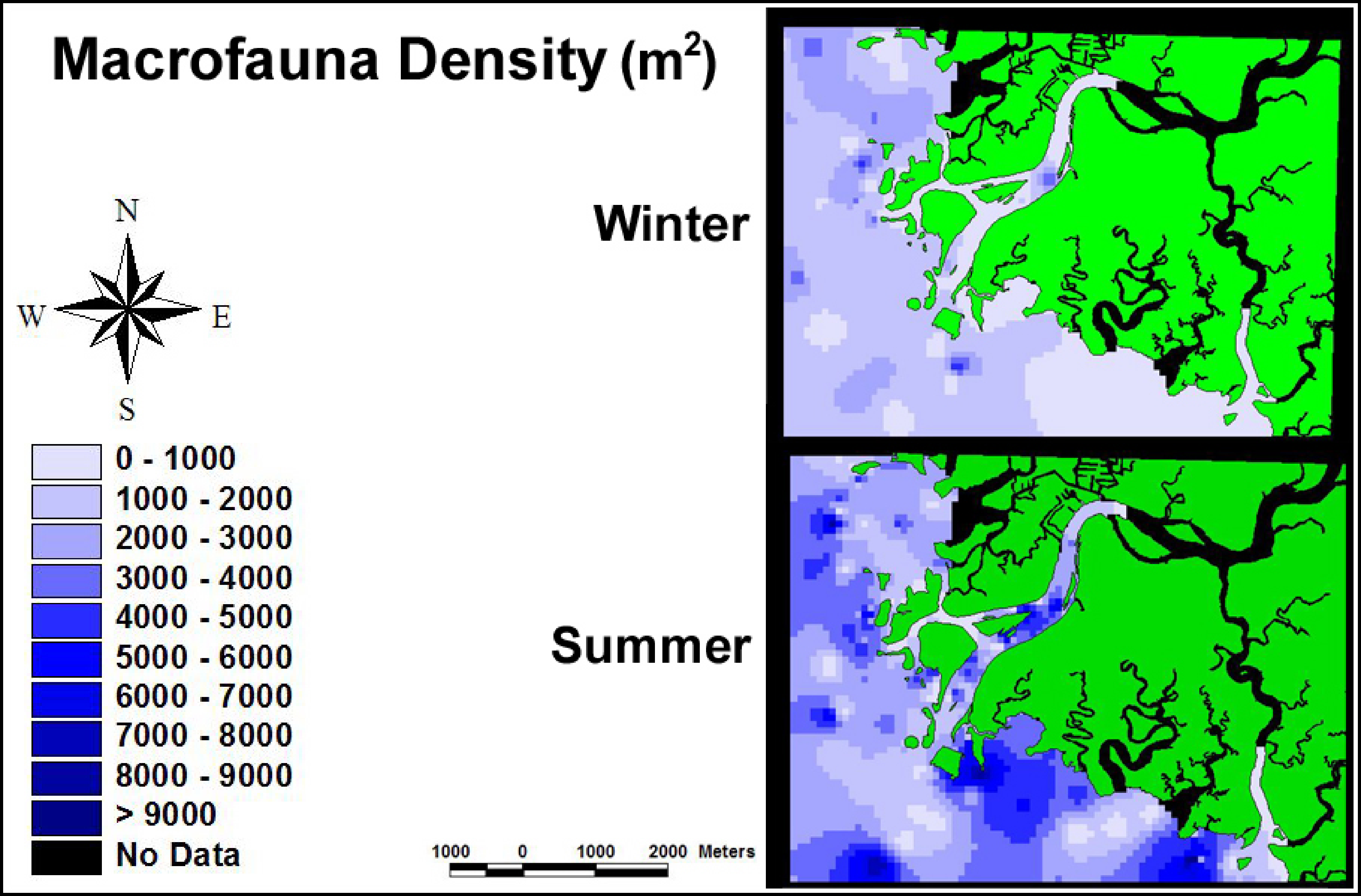
A significant difference in benthic biomass was found between the five different

Table 1. Principal food categories for juvenile Gulf Sturgeon erected from the macrofauna found in the Suwanee River Estuary.

PRINCIPAL FOODS	**SECONDARY FOODS**	**MINOR FOODS**
Brachiopods	Anthozoans	Bivalves
Free-Living Amphipods	Cumaceans	Decapods
Insect Larvae	Nematodes	Gastropods
Isopods	Nemerteans	Ophiuroids
Oligochaetes	Ostracods	
Shrimp	Polychaetes	
	Tube-Building Amphipods	
	Hirudinea	



A.
Macrofauna Density
Summer 2002
Winter 2003
Avg. Density m-2
5000
4000
3000
2000
1000
0
B.
Macrofauna Biomass
Avg. Dry Wt. (g) m-2
14
12
10
8
6
4
2
0
DI
EP
NS
SS
WP
Overall
Location



Macrofauna Density (m2)
N
W
E
S
0 - 1000
1000 - 2000
2000 - 3000
3000 - 4000
4000 - 5000
5000 - 6000
6000 - 7000
7000 - 8000
8000 - 9000
> 9000
No Data
1000 0 1000 2000 Meters
Winter
Summer

estuarine sectors for both summer and winter samples (P=0.007 and 0.001, respectively, ANOVA on Ranks). In both summer and winter, biomass was significantly greater in the North Sound sector compared to the West Pass sector (Figure 4b). Additionally, biomass in both the North and South Sound sector was significantly greater than that of West or East Pass sectors in the winter. Patches of high biomass can be found throughout both Suwannee Sound sectors during both sampling times and in the summer at the mouth of West Pass (Figures 6a,b).

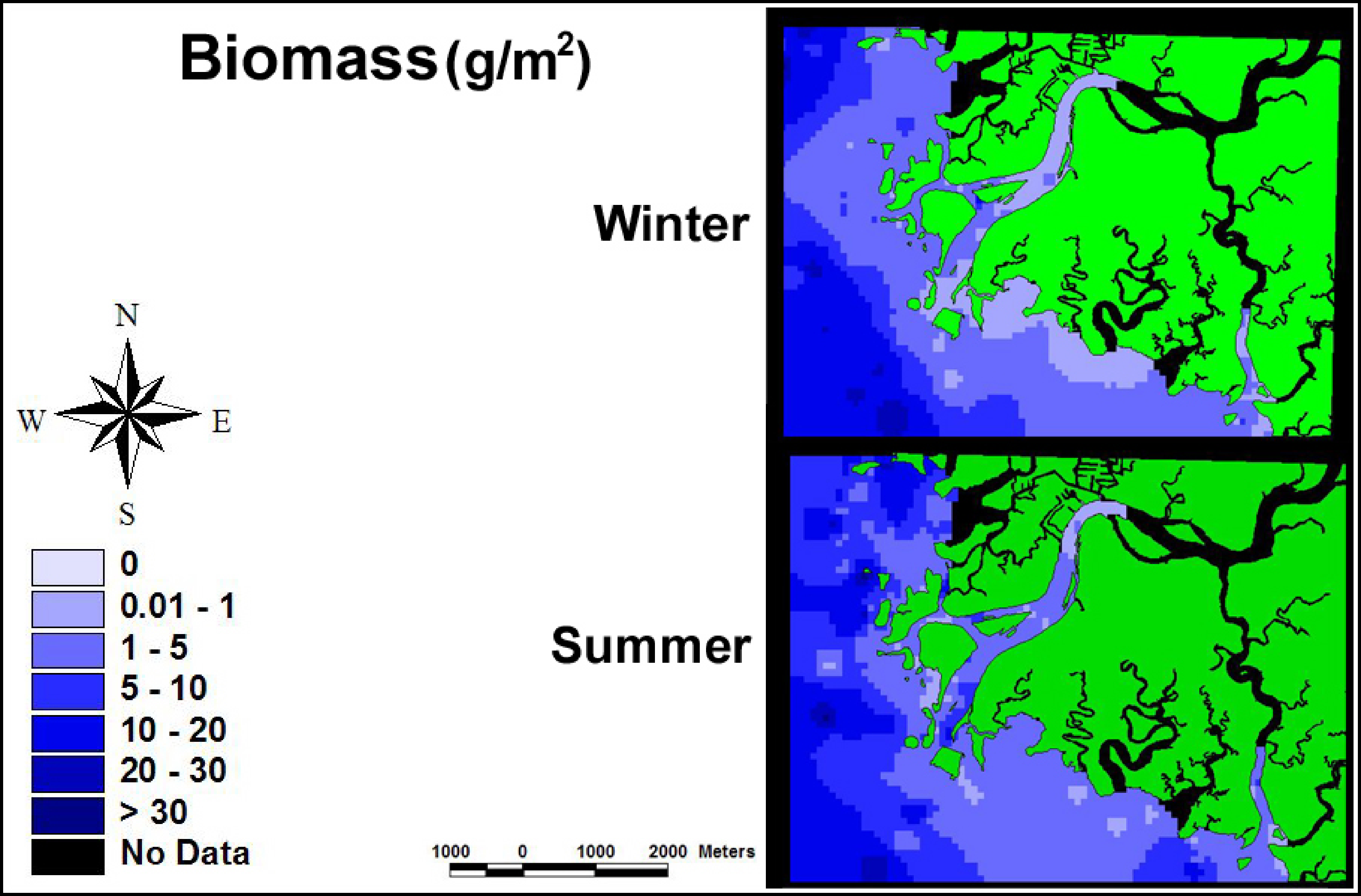
Amphipods and polychaetes were the numerically dominant fauna collected in this study (Figure 7). Although ANOVA on ranks results indicate a significant difference in amphipod density among estuarine regions in the summer (P=0.023), results of a Dunn's Multiple Comparisons Test indicated no significant differences. Areas of high amphipod abundance in the summer can be found in both the South Sound and West Pass (Figure 8a) which both along with the North Sound had a significantly greater amphipod density than East Pass in the winter (P=0.001, ANOVA on Ranks). Overall, amphipod density was more homogeneous throughout the study area in the winter with smaller patches of high amphipod density (Figure 8b). Amphipod species richness was higher in the summer (n=10) compared to winter (n=7) (Table 2). One amphipod species, *Ampelisca abdita*, dominated in both the winter and summer accounting for 58% of all amphipods collected. *Parahaustorius* spp. (14.4% of all amphipods collected, summer and winter) was also commonly collected. *Cerapus tubularis* (15.3% of all amphipods collected, summer and winter) was relatively dominant in the summer samples while *Gammarus mucronatus* (1.8% of all amphipods collected, summer and winter) was relatively common in the winter samples.

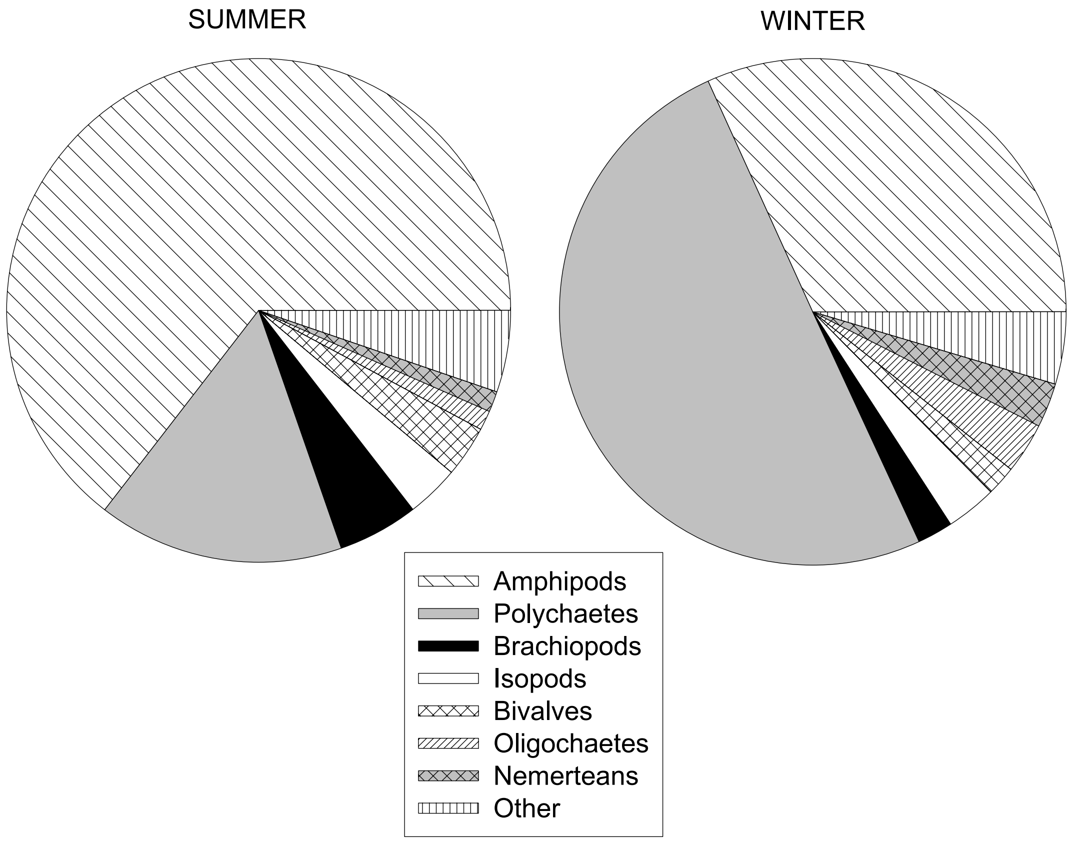
Polychaete density was higher in the North Sound compared to all other estuarine sectors in the summer (P=0.001, ANOVA on Ranks). An interpolated map of summer polychaete density indicates a large patch of high density in the North Sound with smaller patches in West Pass (Figure 9a). Polychaete density in the winter was significantly greater in both Sound sectors compared to West Pass and significantly greater in the North Sound than in East Pass (P=0.001, ANOVA on Ranks). An interpolated map of polychaete density in the winter indicates a large area of high density in both the North and South Sound (Figure 9b). *Melinna (cf. cristata)* dominated in both the winter and summer accounting for 39% of all polychaete species (Table 3). *Tharyx* sp*., Parandalia americana, Glycera americana, Leitoscoloplos (cf. robustus),* and *Aricidea philbinae* were also relatively abundant representing 14%, 10%, 6%, 5%, and 4%, respectively, of all polychaetes collected in both the summer and winter combined.

The stalked brachiopod, *Glottidia pyramidata*, and isopods were also relatively important taxa, representing between 2-5% and 3%, respectively, of the macroinvertebrates collected, respectively. The stalked brachiopod is a common food resource for adult Suwannee River Gulf sturgeon (Harris, 2003). Brachiopods were found only in the outer part of Suwannee sound, with higher densities in the summer (Figures 10a,b).

B) Principal Foods

Interpolated maps for only the Principal Foods category are shown in Figure 11a,b.


Biomass (g/m2)
Winter
Summer
N
W
E
S
0
0.01 - 1
1 - 5
5 - 10
10 - 20
20 - 30
> 30
No Data
1000 0 1000 2000 Meters


SUMMER
WINTER
Amphipods
Polychaetes
Brachiopods
Isopods
Bivalves
Oligochaetes
Nemerteans
Other

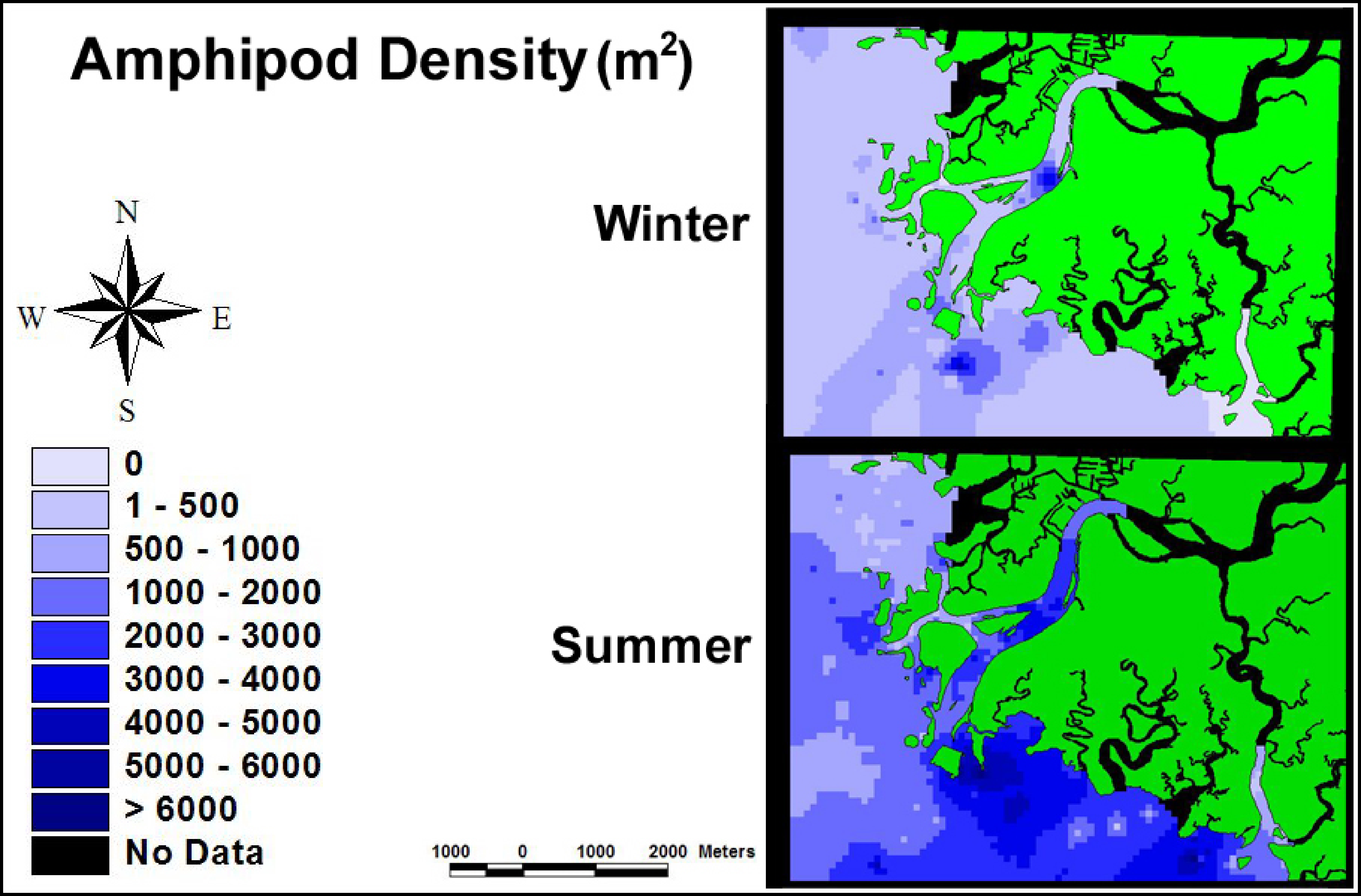
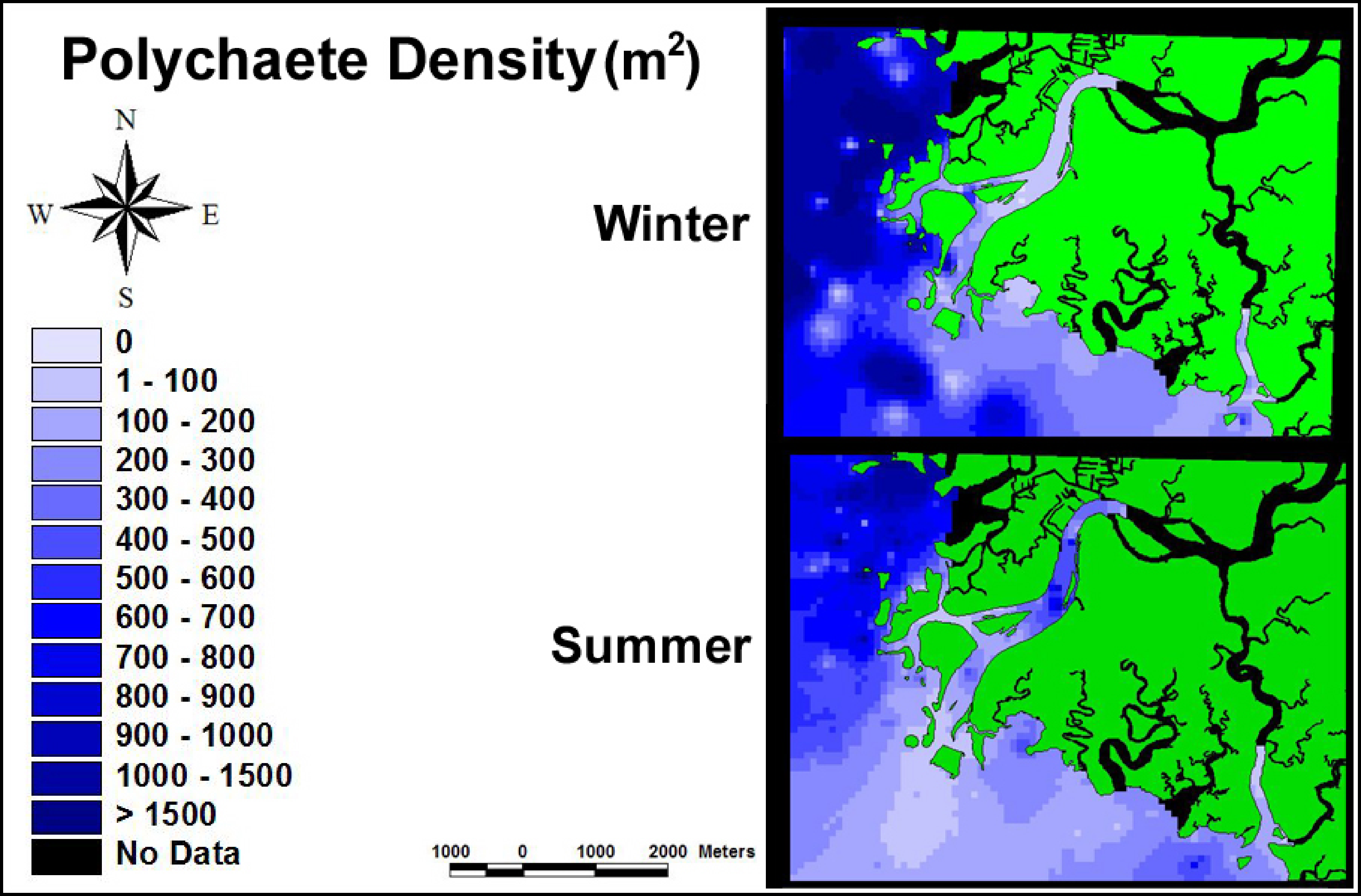

Amphipod Density (m^2)
N
W
E
S
Winter
Summer
0
1 - 500
500 - 1000
1000 - 2000
2000 - 3000
3000 - 4000
4000 - 5000
5000 - 6000
> 6000
No Data
1000
0
1000
2000
Meters

Table 2. Percent representation of amphipod taxa collected in summer, winter and overall samples.

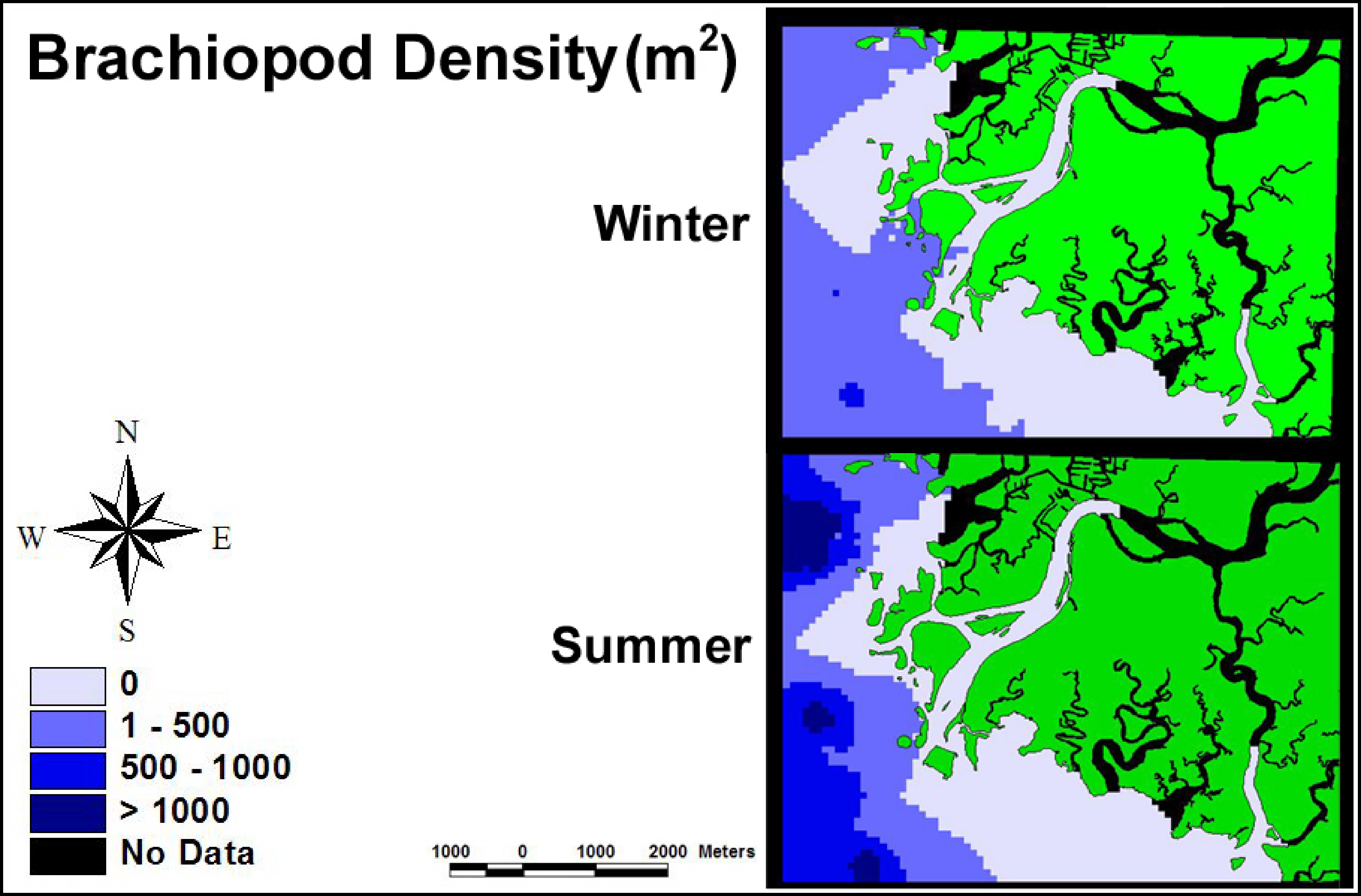
Species	Percent of Amphipods Collected in the Summer	Percent of Amphipods Collected in the Winter	Overall Percent of All Amphipods Collected
Ampelisca abdita	60.5	48.5	58.9
Cerapus tubularis	17.2	3.3	15.3
Haustoriidae	10.5	39.1	14.4
Ampithoe longimana	5.5	1.3	4.9
Corophium simile	4.2	1.2	3.7
Gammarus mucronatus	1.1	6.1	1.8
Cymadusa compta	<1.0	0	<1.0
Melita nita	<1.0	0	<1.0
Stenothoe minuta	<1.0	<1.0	<1.0
Luecothoe spinicarpa	<1.0	0	<1.0

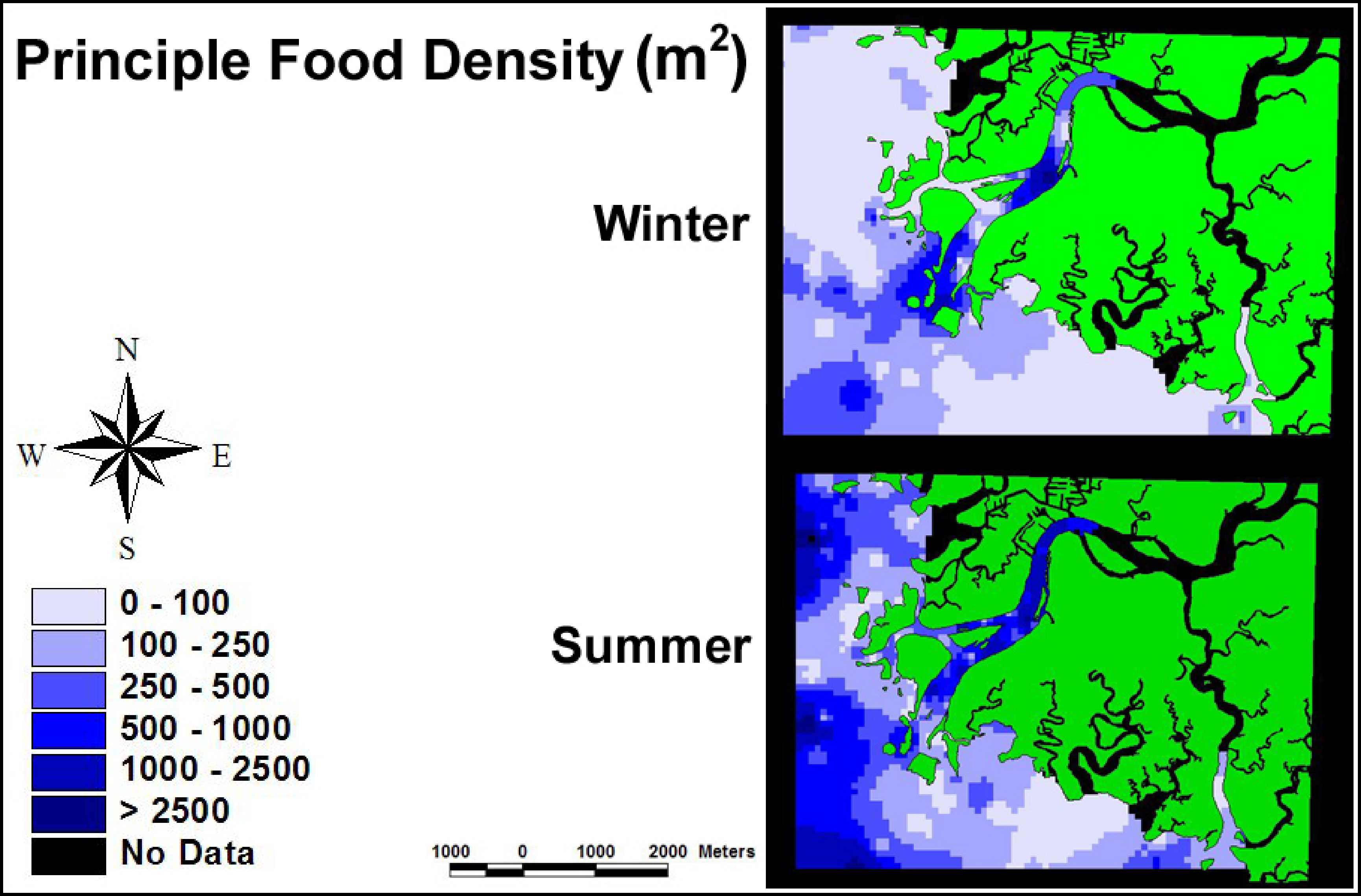


Polychaete Density (m2)
N
W
E
S
0
1 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1500
> 1500
No Data
1000
0
1000
2000
Meters
Winter
Summer

Table 3. Percent representation of the dominant polychaete taxa collected in summer, winter, and overall samples.

Species	**Percent of Polychaetes Collected in the Summer**	**Percent of Polychaetes Collected in the Winter**	**Overall Percent of All Polychaetes Collected**
Melinna (cristata?)	25.1	51.9	39.0
Tharyx	17.9	9.6	13.6
Parandalia americana	15.2	5.8	10.3
Glycera americana	7.0	5.8	6.4
Leitoscoloplos (robustus?)	9.0	1.6	5.2
Aricidea philbinae	<1.0	7.2	3.8
Kinbergonuphis	6.2	<1.0	3.4
Paraspionospio pinnata	1.9	4.6	3.3
Websterinereis	4.6	1.8	3.2
Anaitides mucosa	3.5	<1.0	1.8
Malanidae	3.7	0	1.8
Pectinaria gouldii	2.4	<1.0	1.5
Unidentified sp.	0	2.6	1.4
Neanthes succinea	1.2	<1.0	1.0
Other	1.3	5.4	4.3


Brachiopod Density (m2)
Winter
Summer
N
W
E
S
0
1 - 500
500 - 1000
> 1000
No Data
1000
0
1000
2000
Meters


Principle Food Density (m2)
Winter
Summer
N
S
W
E
0 - 100
100 - 250
250 - 500
500 - 1000
1000 - 2500
> 2500
No Data
1000 0 1000 2000 Meters

High densities of Principal Food items are found in West Pass and the outer Sound in the summer. A similar pattern is found for the winter with a high density of principal food items throughout West Pass and in the Sound by the mouth of West Pass.

The Biased Food Density measure indicates high summer values in West Pass and the near-shore area of the South Sound (Figure 12a). A few small patches of high density, are also observed in the outer Sound. Only a few spots stand out in the winter (Figure 12b), but a pattern is still present that is similar to the summer.

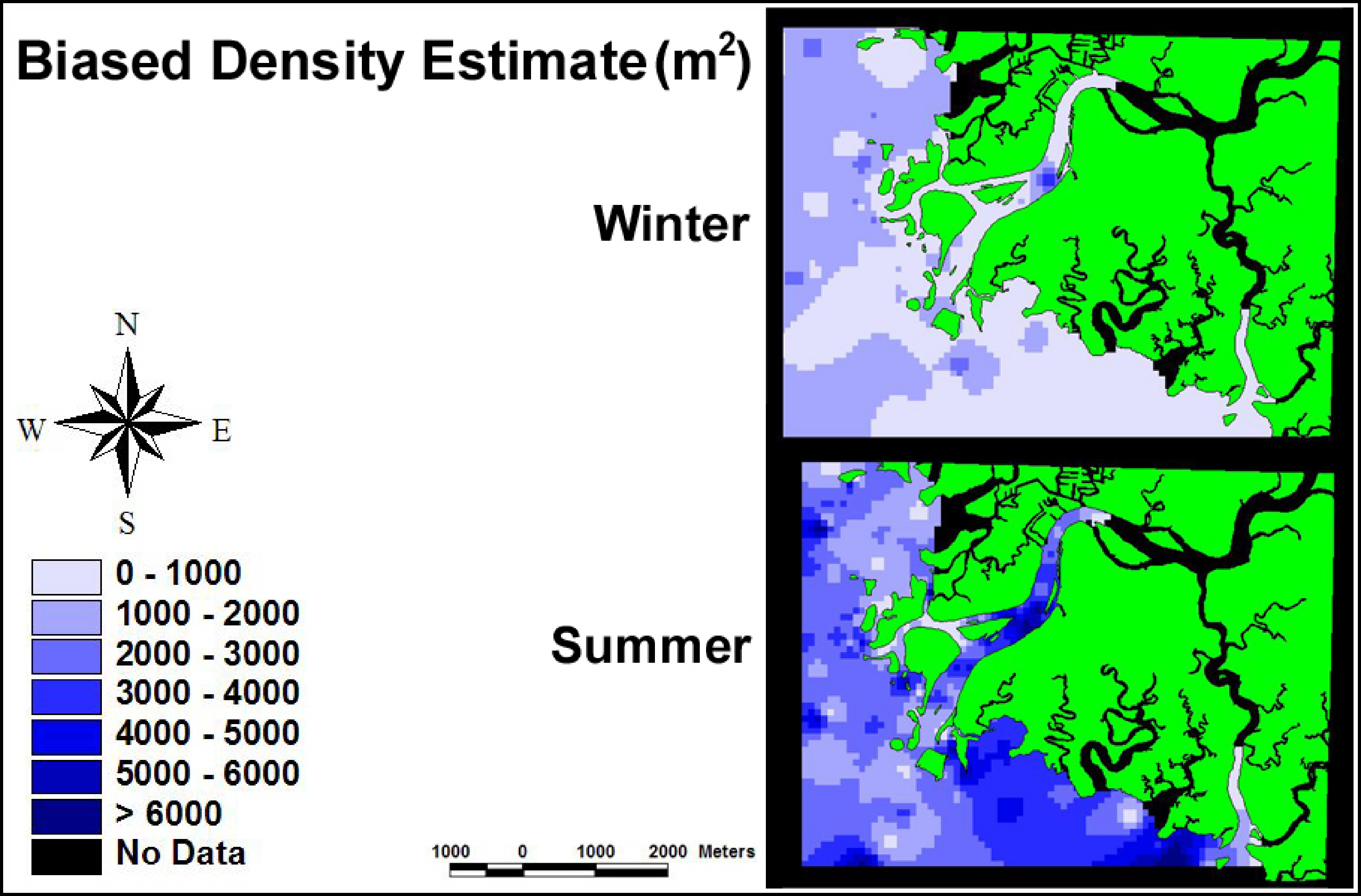
The Adjusted Food measure, which combines both density and biomass, indicated that the main areas of potential high food value were located in the outer Sound in both the summer and winter (Figures 13a & 13b). The density of brachiopods was mathematically driving this pattern in the summer, but the pattern persisted in the winter, when brachiopod abundance was reduced.

Discussion

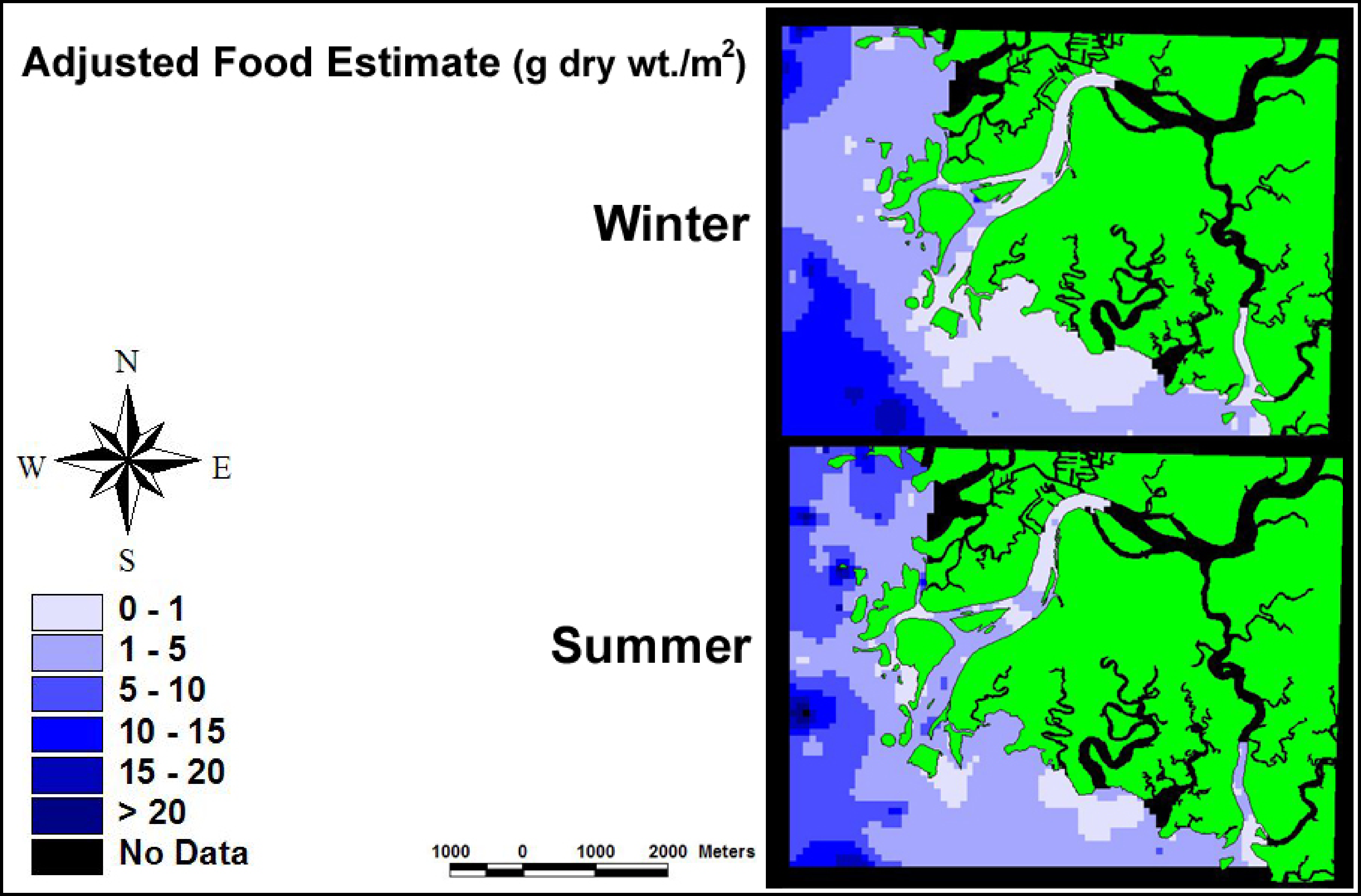
Macrofaunal abundance in the Suwannee Estuary was within the mid range found for other estuaries around the Gulf of Mexico. Macrofaunal densities ranged from 0-13,701 individuals/m^2 with an average density of 1,935 (s.e. $\pm$ 137) individuals/m^2. Present estimates of benthos density in the Suwannee Estuary are higher than those found for Mobile Bay, AL (TechCon, 1980); Neches River Estuary, TX (Harrel & Smith, 2002); Nueces Bay, TX (Mannino & Montagna, 1997); and Santa Rosa Sound, FL (EPA, 1975). But Suwannee estuary estimates are not as high as values reported for Mississippi Sound, MS (USACE, 1982); Tampa Bay, FL (Culter, 1995); and Rookery Bay, FL (Sheridan, 1997). Although macrofaunal population density differences among the five estuarine sectors were only found for the winter sampling, the distribution of macrofauna was very patchy. Areas of high population density were found throughout the Sound and in part of West Pass, regardless of sampling season. In contrast to these results, no significant differences were found for macrofaunal densities among salinity regions in Nueces Bay, TX. Seasonal differences in benthos density were also found in the Suwannee Estuary with abundances over two times greater in the summer compared to winter.

Benthic biomass (dry weight) ranged from 0-41 g/m^2 with an average of 4.8 (s.e. $\pm$ 0.5) g/m^2. Biomass estimates were almost 50% higher in the summer than in winter. Patches of high biomass were found in areas of higher salinity (e.g., Suwannee Sound), similar to results from Nueces Bay, Texas (Mannino & Montagna, 1997). Overall, the range of biomass values found in the Suwannee Estuary were substantially greater than the range reported from Nueces Bay (<1-9.23 g/m^2). In the Suwannee estuary, average benthic biomass was higher than above the salt wedge (RKMS 52-64, 0.5 g/m^2 $\pm$ 0.1) (Sulak et al., in press).

Amphipods were the dominant taxa in the summer with most species being tubicolous. The spatial distribution of amphipod density displays a clear spatial correlation between high density and freshwater flow. West Pass and parts of the South Sound, which predominantly receive the freshwater plume, contained relative hot spots of amphipod density compared to the rest of the study area. Amphipod distribution may not be



Biased Density Estimate (m2)
Winter
Summer
N
S
W
E
0 - 1000
1000 - 2000
2000 - 3000
3000 - 4000
4000 - 5000
5000 - 6000
> 6000
No Data
1000 0 1000 2000 Meters



Adjusted Food Estimate (g dry wt./m²)
Winter
Summer
N
W
E
S
0 - 1
1 - 5
5 - 10
10 - 15
15 - 20
> 20
No Data
1000 0 1000 2000 Meters

responding solely to the low salinity regime. Sediment deposition, particulate organic content, and/or high oxygen content as well as freshwater inflow stimulated primary and secondary production may also influence amphipod distribution (Mannino & Montagna, 1997; Kimmerer, 2002). *Ampelisca,* by far the most common amphipod genus collected, are filter feeders and have been noted for their vulnerability to sediment quality. They are often used as indicator species for heavy metals and PAH organic compounds in toxicology studies (ASTM, 2003; Gomez Gesteira & Dauvin, 2000). A high density of ampeliscans in the Suwannee River Estuary suggests low sediment contamination levels.

Polychaetes were the dominant taxa collected in the winter. The spatial distribution of polychaetes was opposite that of amphipods. Polychaete density was highest in the North Sound away from the freshwater influence of the river. *Tharyx*, a tube building deposit feeder, was commonly found in both the winter and summer. Free burrowing *Leitoscoloplos* and *Parandalia* were typical genera collected in the summer. *Leitoscoloplos* is a deposit feeder, while *Parandalia* is suspected to be a carnivore. *Melinna*, a tube builder and surface deposit feeder was the dominant polychaete taxon collected in the winter (Fauchald & Jumars, 1979).

Brachiopod distribution within the Suwannee Estuary is restricted to outer Sound areas and appears to be associated with hard substratum provided by oyster shell material. Brachiopods can be found in patches of high density (> 6,000 individuals m^{-2}) in the summer but have reduced abundance in winter. It is unknown if juvenile sturgeon utilize brachiopods as an important prey item although adults utilize them heavily (Harris, 2003).

Tubiculous amphipods and polychaetes, although consumed by juvenile sturgeon, do not appear to be principal food items based upon gut content analysis (Huff, 1975; Mason & Clugston, 1993). Brachiopods were included in the principal foods category for this analysis based upon adult gut contents (Harris, 2003), but their inclusion needs to be re-evaluated as more diet information becomes available. Other than brachiopods, isopods and oligochaetes are also important potential food resources in the estuary. Isopod density is highest near the lower parts of the river passes, while oligochaetes have a pocket of high density in the North Sound.

Depending upon which quantitative measure is used to evaluate potential resource value for juvenile Gulf sturgeon foraging, different locations within the estuary stand out. When examining the distribution of only those taxa which were assigned to the Principal Food category, high densities are found throughout West Pass and in the South Sound by the mouth of West Pass. The pattern is consistent regardless of sampling date. The Biased Food Density measure highlights not only areas of West Pass as containing high potential resource value but the outer Sound areas and the near-shore area of the South Sound as well. In the winter, the distribution of high resource areas based upon the Biased Food estimate is fairly homogeneous with relatively few hot spots. Values of the Adjusted Food measure are highest in the outer Sound areas away from the river mouth.

Interestingly, the Adjusted Food measure does not highlight West Pass as an area of high resource value for juvenile sturgeon and the Biased Food Density estimate is only high in West Pass during the summer. Historical sampling within West Pass however has indicated that juvenile sturgeon are consistently found within this area, as documented in the U. S. Geological Survey (USGS) Suwannee River Gulf sturgeon database (Figure 14). Therefore, without any additional information on juvenile habitat use it appears that the Principal Food Density estimate is the best predictor of potential food resources for juvenile Gulf sturgeon. Adult sturgeon have been found to follow what appears to be a Levy search pattern when foraging such that an initial search direction is chosen at random and followed linearly until a patch of prey is located, after which movements become random within a confined area (Edwards et al., 2003). Therefore, prey density and prey patch size are possibly more important than prey biomass for juvenile Gulf sturgeon. Estimates which incorporate an indicator of biomass such as the Adjusted Food measure maybe more important for other benthic fishes (e.g., Spot, Croaker, Flounder) with alternative foraging strategies.

The measures calculated in this study provide a static assessment of potential food resources (density and biomass) that may need to be adjusted if benthic feeding fishes such as the Gulf sturgeon continuously feed within the same area. In this regard, we lack data on benthic productivity. A sector may initially have relatively high benthic resources before it is foraged, but recovery time is unknown. An area with a low recolonization rate may not be as valuable for sturgeon over the winter feeding season compared with an area with a higher recolonization rate (i.e., populated by fast reproducing amphipods). Thus, there may be a trade-off between immediate and long-term resource value in a given area.

The quantitative measures used in this study have identified areas which are potentially sensitive to disturbance by dredging and/or spoil disposal. The Principal Food Density estimate is high in Wadley Pass only during the summer when sturgeon residence within this area is potentially low. Thus, dredging Wadley Pass in either the winter when there is a low food density or summer would seem to present a low potential for long-term impact on critical juvenile sturgeon trophic habitat.

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